THE INSURANCE MARKET PLACE AS A NEXUS FOR CATALYZING SYNERGISMS BETWEEN CLIMATE CHANGE MITIGATION AND ADAPTATION

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"Challenges in Integrating Mitigation and Adaptation as Responses to Climate Change."

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ABSTRACT

The insurance industry is both a barometer of the changing climate and a market actor that can play a material role in decreasing the vulnerability of human and natural systems to weather-related natural disasters while simultaneously supporting both its own market-based objectives and the objectives of sustainable development generally, and mitigation and adaptation measures in the context of global climate change in particular. Although insurance is not a "silver bullet" for the problems posed by natural disasters, the insurance sector has significant capacity and ability to spread the risks and manage the costs of weather-related events, more so today in industrialized countries but increasingly slow in developing countries and economies in transition. Promising strategies involve establishing innovative products and systems for delivering insurance and using technologies and practices that both reduce vulnerability to disaster-related insurance losses and support sustainable development (including reducing greenhouse gas emissions). Specific examples are provided for the energy sector and for agriculture, forestry, and land use.

Introduction

The insurance sector integrates risks of extreme weather events across virtually all sectors of the economy. The core business of insurance, as well as the sector's activities in financial services and asset management are vulnerable to climate change (Table 1). As such it is both impacted by, and stands to be a central force for responding to climate change (Vellinga et al. 2001; Mills 2004).

The argument has been made that insurance can play a substantial role in managing and spreading the risks associated with extreme weather events, both because of its financial capacity and its ability to encourage loss-reducing behaviors more effectively than public-sector efforts (World Bank 2002). By pooling risks among all those insured, insurers reduce the potential exposure of any individual to a manageable level; this approach to risk spreading helps ensure that funds are available to pay for losses.[1] In addition to pooling risks, insurers often serve as proactive risk managers, e.g., by endorsing (or requiring) loss-prevention behaviors or technologies. Examples include insurers' historical role in creating building codes, fire departments, and Underwriters Laboratories product-safety labeling (Mills et al. 2001).

[1] Of course, insurers can become insolvent (bankrupt) following catastrophic events although this is the exception to the rule, and solvency is less of an issue for insurers than for individually "self-insured" households or businesses.

More recently, insurers have begun to promote practices that simultaneously contribute to loss-prevention and enhance sustainability, particularly in energy use and management (Mills 2003a), e.g. by promoting distributed electricity generation to reduce risks of power disruptions and energy-efficiency strategies that reduce vulnerability to freeze damage and provide off-grid lighting or water purification (which are important in disaster recovery). By helping spread the risks and costs of damages and by fostering disaster resilience in the face of rising losses, the insurance industry can help build adaptive capacity to climate change while helping to mitigate the core risks posed by increasing greenhouse gas emissions.

Table 1. Climate-Change Threats and Opportunities for the Insurance Industry

Financial Sector Activity	Threat	Opportunity
General Financial Services	• New and existing markets become unviable as climate change increases regional exposure	• New markets/products related to mitigation projects/processes
	• Macroeconomic downturn due to actual impacts	• New markets/products related to adaptation projects/processes
	• Compounding of climate change risk across entire portfolio of converging activities (asset management, insurance, reinsurance).	• Public/private partnerships for commercially unviable markets
	• Unforseen changes in government policy	• Technology insurance and/or contingent capital solutions to guard against non-performance of clean energy technologies due to engineering failure.
Property/Casualty Insurance	• Physical damage to insured property from extreme/more frequent weather events, compounded by unmanaged development, resulting in volatile results and liquidity and credit rating problems	• Increases in demand for risk transfer and other services as weather risks increase
	• Increased risk in other lines of business (e.g. construction, agriculture, transport)	• Insurance of mitigation projects
	• Increases in population and infrastructure densities multiply the size of maximum potential losses from extreme weather events	• Innovative risk transfer solutions for high-risk sectors
Life/Health Insurance	• Increased risk to human health (thermal stress, vector-borne disease, natural disasters).	• Increase in demand for products as human health risk rises
Other	Business interruption risks becoming unpredictable and more financially relevant	• Collaboration with others in pooling capital
	• Disruptions to construction/transportation sectors	• Microinsurance
	• Increased losses in agro-insurance	• Weather Derivatives, CAT Bonds, etc.
	• Political/regulatory risks surrounding mitigation	
Asset Management	• Hidden GHG liabilities impair market values of securities	• Investment in climate leaders and best-in-sector securities
	• Real estate impaired by weather events and inceased energy costs	• Innovative climate-related theme funds
	• Potential absence of property insurance	• Consulting/advisory services.
		• Hedge funds investing in GHG credits

Source: Adapted from UNEP and Innovest (2002)

While the majority of economic impacts from weather-related natural disasters and insurance payouts for such losses are today located in industrialized countries, those in developing nations and economies in transition (referred to together as "emerging markets" by insurers and in this article) are significant and growing at a greater rate. For these reasons, this article gives special emphasis to the problems in opportunities in these regions.

Three key types of activities could support the coupling of insurance and sustainable development:

- Generating information, training, and analysis to help make emerging markets attractive (i.e., less risky) for insurers;
- Identifying and deploying sustainable technologies to help emerging markets simultaneously adapt to and mitigate natural disasters; and
- Fostering innovative insurance products and financing mechanisms to increase this form of risk spreading.

A major challenge lies in setting priorities and developing the public-private partnerships necessary for success.

The objectives of this article are:

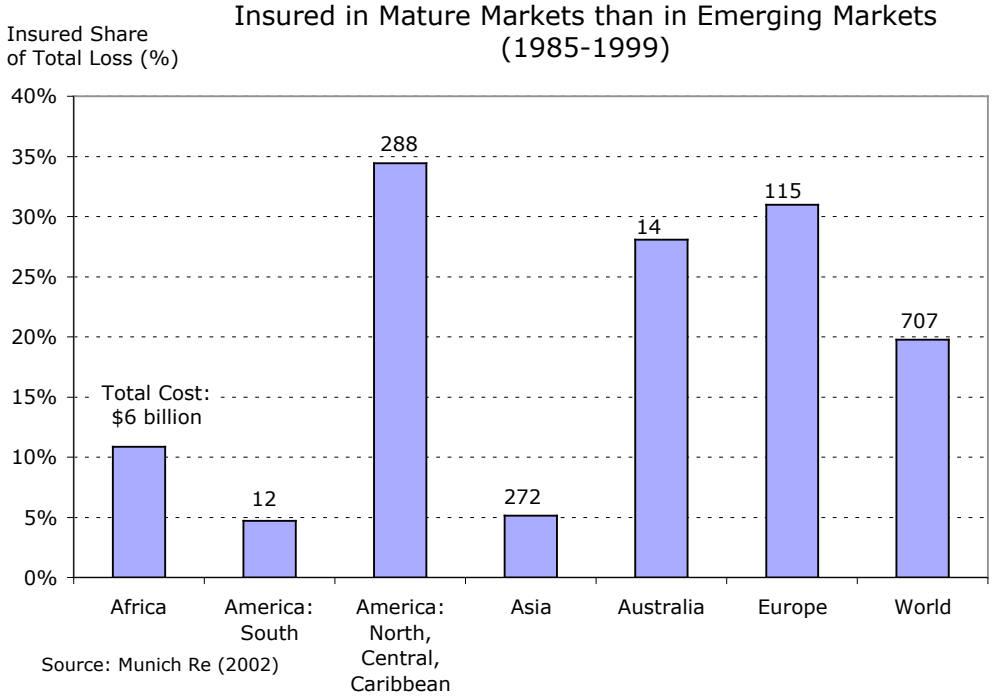
- To sketch out insurance market and its global role in risk spreading as well as its own vulnerabilities to climate change.
- To establish the ability and rationale for insurers to engage in climate change mitigation and adaptation.
- To explore a subset of potential activities that simultaneously embody both mitigation and adaptation benefits.
- To identify potential avenues of involvement for insurers—as well as the limitations—and recommendations for cultivating effective partners among insurers and public-sector entities.

The Insurance Industry[2] Can Play a Material Role in Decreasing Society's Vulnerability to Weather-Related Natural Disasters while Supporting its Market Objectives and Sustainable Development.

From 1980 through 2003, the economic costs of all weather-related natural disasters totaled $1 trillion ($2003), divided approximately 40/60 between wealthy and poor countries, respectively (Munich Re 2004). Between 1980 and 2003, insurance covered four percent of the total costs of weather-related disasters in low-income countries and 40 percent in high-income countries (Figures 1 and 2). Insurance payments associated with these losses in emerging markets are three-times the amount of international aid provided for these events, and availability and use of insurance is growing while international aid levels remain roughly level. Insurance is thus a promising vehicle for complementing international aid and improving adaptive capacity in wealthy and poor countries alike.

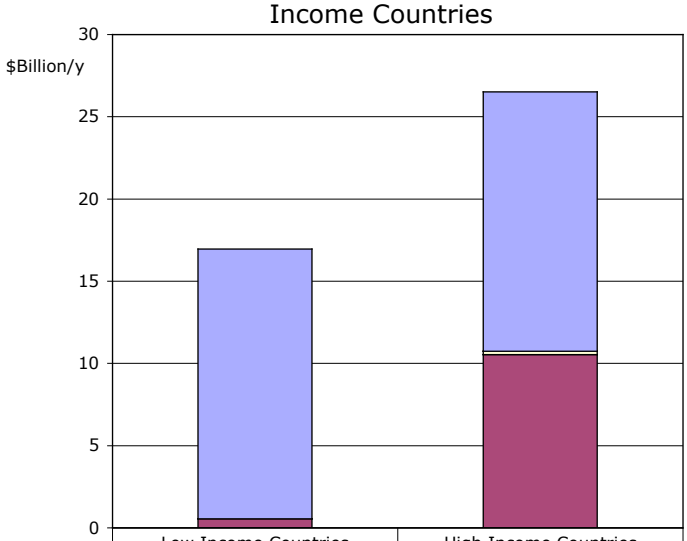
[2] Unless otherwise noted, the terms "insurance" and "reinsurance" are used synonymously in this report.

Figure 1. A Greater Share of Weather-Related Losses are Insured in Mature Markets than in Emerging Markets (1985-1999)



Source: Munich Re (2002)

Figure 2. A Small Proportion of Weather-Related Disaster Costs Are Absorbed by Insurers in Lower-Income Countries

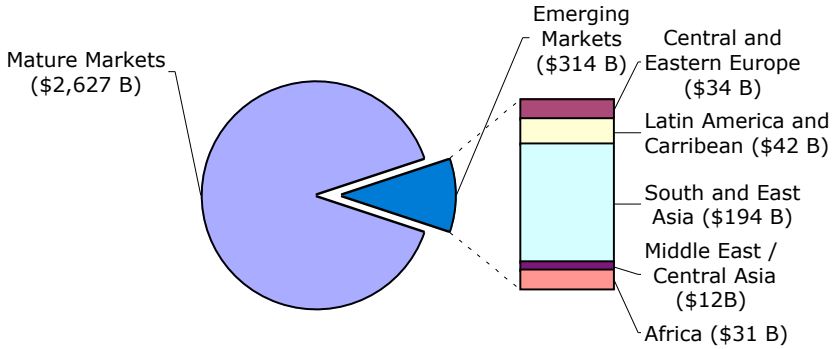


	Low Income Countries	High Income Countries
Domestic governments & Individuals	16.40	15.79
Internationnal Aid	0.00	0.20
Insurers & Reinsurers	0.55	10.53

Notes: Periods over which yearly averages are determined: Total: 1980-2003, Insurance: 1980-2003, AID: 1992-2003. Sources: http://www.reliefweb.org (disaster relief); Munich Re 2004 (insurance and total economic costs; low-income defined as property/casualty premiums of $100/capita-year or less). Value for domestic governments & individuals is the residual. Aid donors include those tabulated by OCHA: UN Agencies, donor governments, international organizations, the Red Cross, and NGOs (excludes purely military aid).

Nonetheless, the penetration of insurance in emerging markets is low compared to that in industrialized countries. Insurance premiums in emerging markets as of the year 2003 totaled approximately $314 billion (up from $270 billion just a year earlier), or 11 percent of the global market (Figure 3).

Figure 3. Eleven Percent of $2.9 Trillion/year Global Insurance Market is in Developing Countries and Economies in Transition: 2003

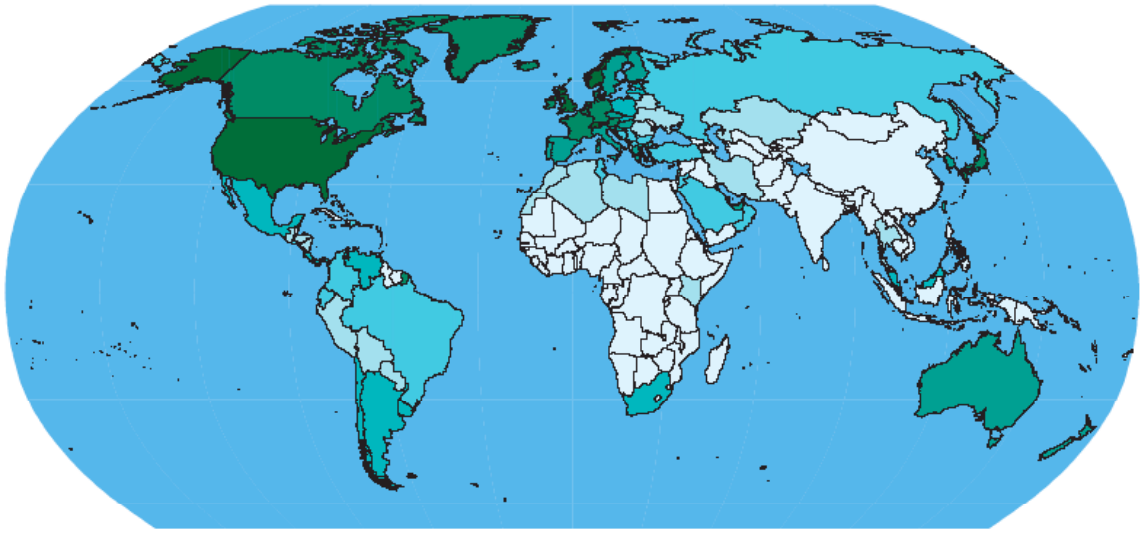


Source: Swiss Re, Economic Research & Consulting, Sigma No. 3/2004 [Swiss Re (2004)]l.
Includes property/casualty and life/health insurance.

Traditional responses to the impacts of extreme weather events are critical but woefully inadequate. International aid today absorbs only one percent of total weather-related disaster costs in emerging markets and is consistently less than the level of assistance requested by impacted countries. With the rate of weather-related losses increasing dramatically, rising natural-disaster costs in aid-receiving countries, and growing demand for other forms of aid, relief aid is unlikely to absorb a greater share of the costs of natural disasters in the future.

Although insurance is not a panacea for the problems posed by weather- and climate-related risks, it can help manage costs that cannot be addressed by international aid or local governments or citizens. Almost all "lines" of insurance are vulnerable to climate risks, whether they are direct property losses from natural hazards or business interruptions from the disruption of electricity grids or environmental liability claims caused by water contaminated by flood-related runoff from farms. The penetration of insurance varies considerably around the world, as does the type and scale of disasters (Figure 4).

Figure 4. The Use of Insurance varies Widely Around the World



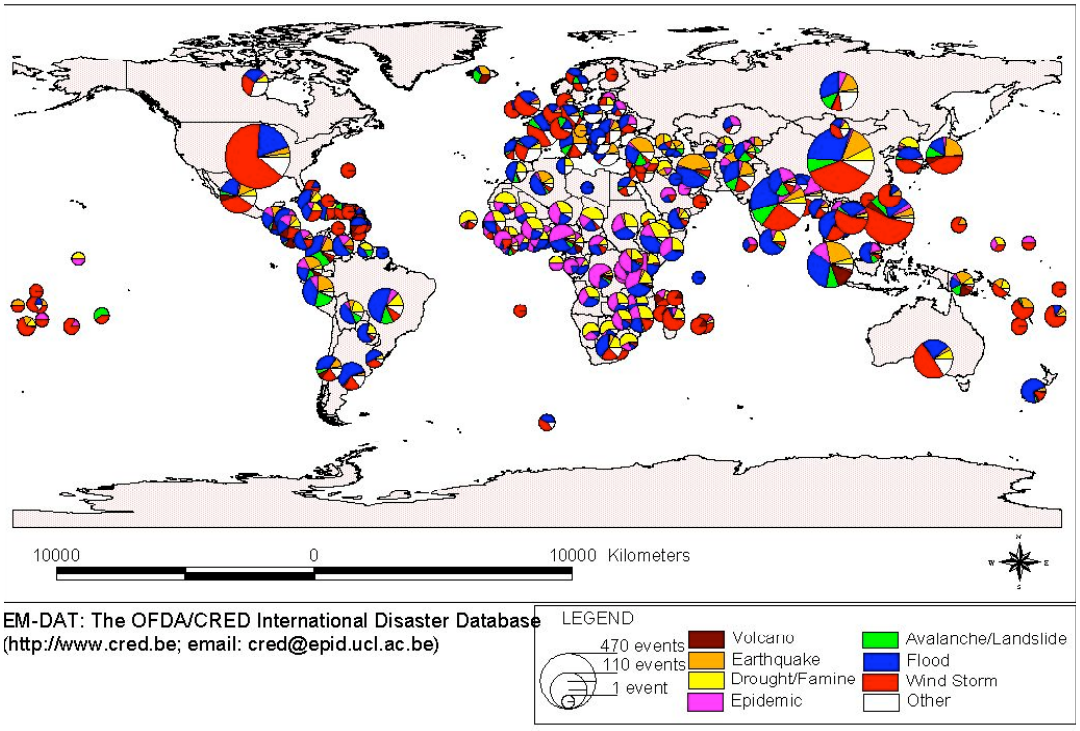
Uninsured group
- US$ 0–5

Basically insured group
- US$ 6–25
- US$ 26–50

Well insured group
- US$ 51–100
- US$ 101–500
- US$ 501–1,000
- US$ 1,000+

Property insurance premium (non-life including health) per capita per year in US$
Source: MR Economic Research/NatCat*SERVICE*®

The Type and Scale of Natural Disasters are Distributed Unevenly: 1975 to 2001

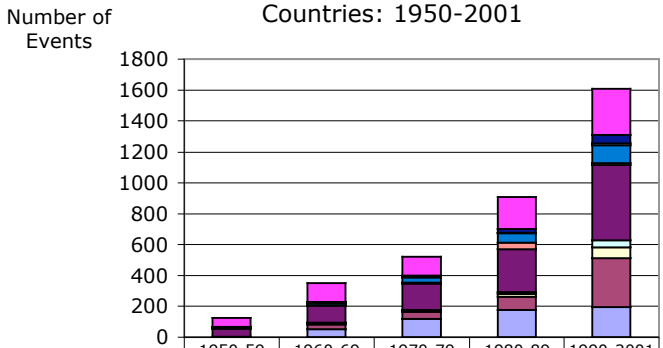


EM-DAT: The OFDA/CRED International Disaster Database
(http://www.cred.be; email: cred@epid.ucl.ac.be)

The ability to adapt to extreme weather events is lowest in the poorest segments of society and in countries where resources, information, and skills are limited; technology is often unavailable; institutions are unstable or weak; and empowerment and access to resources is inequitable (Smit et al. 2001). Properly applied, insurance can play a particularly important role in this setting. These areas are high priority for insurers, because, although not today "large" markets, they are growing at approximately twice the rate of insurance markets in industrialized countries, and the vulnerabilities to climate change are substantially higher – by orders of magnitude in some instances.

According to observations from the Emergency Events Data base (EM-DAT), compiled by U.S. Agency for International Development Office of Foreign Disaster Assistance (USAID/OFDA) and the Center for the Research in the Epidemiology of Disasters (CRED), the number of weather-related natural disasters has risen sharply during the past 50 years (Figure 5).[3] The incidence of weather-related disasters per decade has risen from approximately 100 to 1,600 events during the past 50 years in less-developed countries, with the number of people impacted or killed per decade rising steadily from 15 million during the 1950s to four billion during the 1990s. These trends are a combined result of changes in the nature of natural hazards and demographic factors bringing greater numbers of people into harm's way.

Figure 5. The Frequency of Weather-Related Disasters Has Risen in Less-Developed Countries: 1950-2001

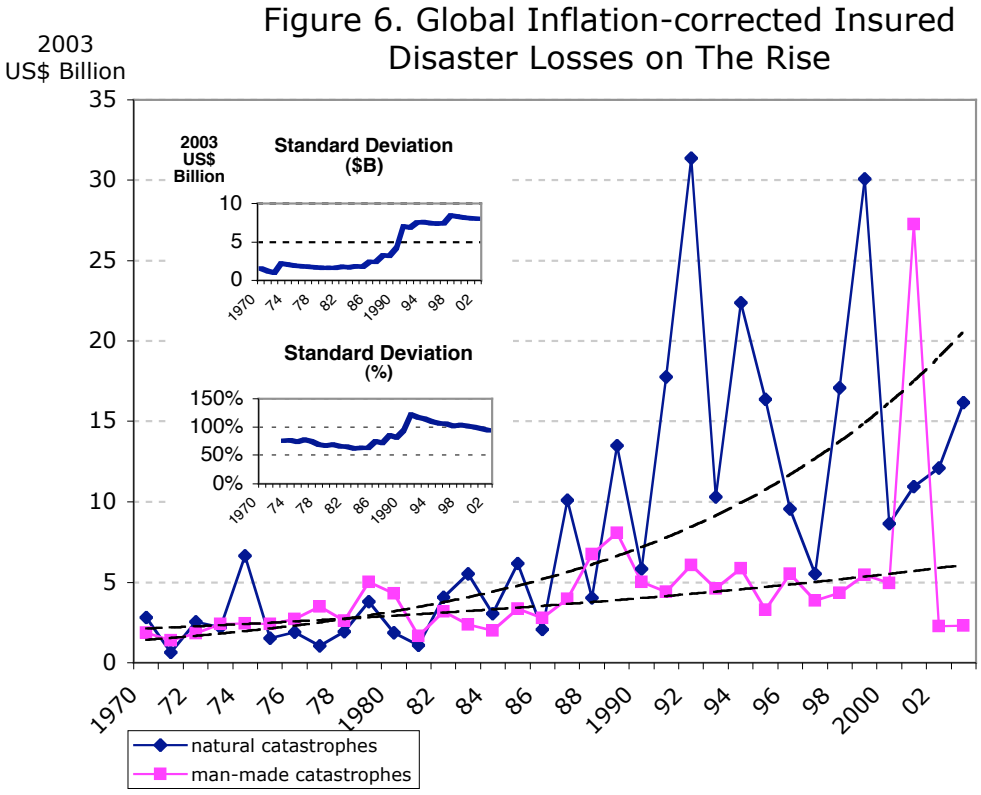


	1950-59	1960-69	1970-79	1980-89	1990-2001
Wind storm	59	121	121	207	300
Wild fire	0	4	11	25	54
Wave/surge	2	5	2	3	12
Slide	11	15	34	63	114
Insect infestation	0	1	6	43	13
Flood	50	110	170	276	489
Famine	0	2	4	11	45
Extreme temp	4	10	9	19	70

Sources: OFDA / Center for Research in the Epidemiology of Disasters (CRED) "Natural.xls" Intl database of Disasters (http://www.cred.be/emdat/intro.html) and U.S. Census Bureau's International Database (http://www.census.gov/ipc/www/idbagg.html). From analysis completed by Padco's Climate Change Solutions Group for USAID's Global Climate Change Team. "Population Impacted" includes those persons that have either been killed, injured, left homeless, or otherwise adversely affected.

[3] As with all such datasets, caveats apply with respect to uniformity over time in data collection methods, data quality, comprehensiveness, etc. A discussion of the EM-DAT data provided by Brooks and Adger (2003) concludes that analyses based on data from 1970 forward are "fairly robust."

Although all losses have increased in absolute terms, the rise in the relative incidence of weather-related events (such as wildfire, extreme temperature episodes, and epidemics) compared to non-weather-related ones (such as volcano eruptions or earthquakes) is particularly notable (Vellinga et al. 2001). The costs of so-called "man-made catastrophes" have also risen more slowly than those of natural catastrophes (Figure 6), as has variability. Note that these increases have happened in spite of significant efforts at loss control, ranging from flood-plain management to improved building codes to increasingly sophisticated early warning and evacuation strategies.



Per Swiss Re's conventions, losses reported here are a subset of the total, including events with losses in excess of $35.1 million or total economic losses in excess of $70.2 million or 20 dead or missing, 50 injured, or 2000 homeless. Source: Swiss Re, Economic Research & Consulting, Sigma 1/2004 [Swiss Re (2004)]. Excludes life/health insurance impacts. Growth rate of weather-related natural catastrophes is greater than that of non-weather-related ones, e.g. earthquake and volcano. Trendlines added.

Even in wealthy nations, governments are increasingly seeking to limit their financial exposures to natural disasters (e.g., the U.S. National Flood Insurance Program will pay out no more than $250,000 per loss per household (McDonald 2003)). The problem is worse in emerging markets where governments are hard pressed to absorb the large costs of natural disasters (which are unpaid by insurers, aid, or individuals). Disruption of economic activity and diversion of government funds to prepare for and recover from natural disasters constrains development.

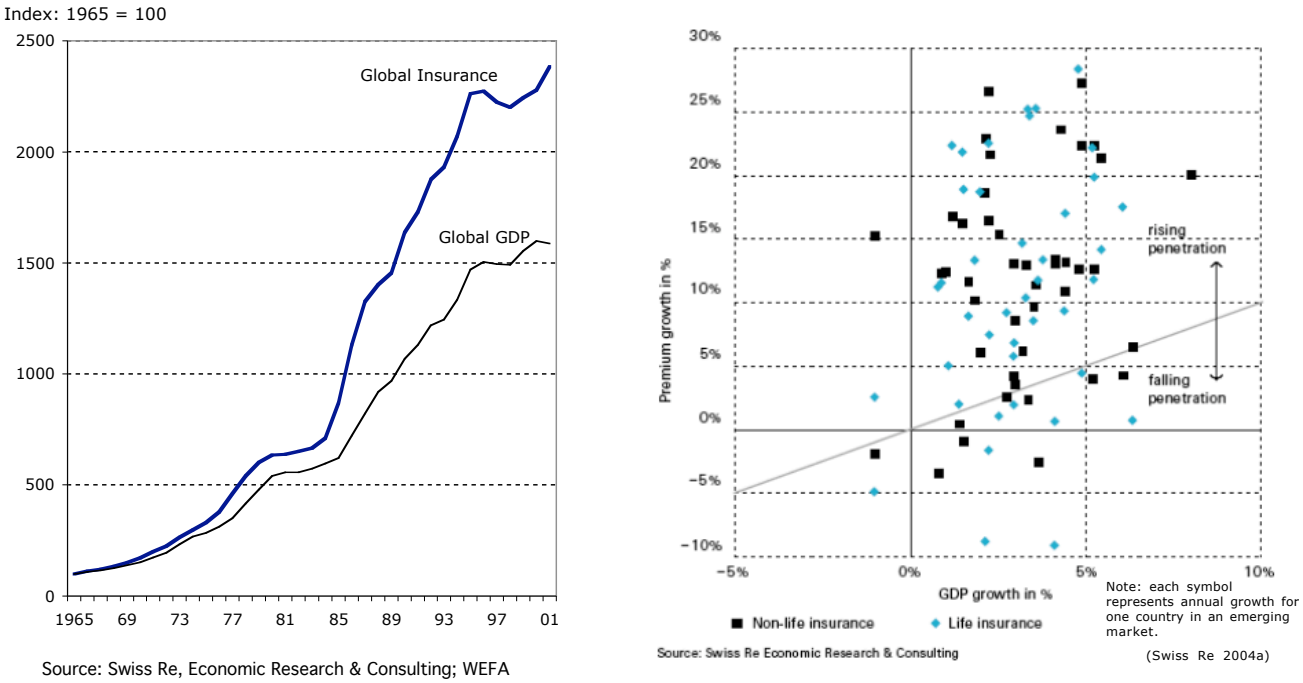
Insurance is the only source of adaptive capacity that is clearly increasing.

The Global Insurance Market Offers Considerable Adaptive Capacity.

Worldwide, insurance companies collected $2.9 trillion in premiums in the year 2003 or about eight percent of global GDP.[4, 5] To put the size of the insurance industry in perspective: comparing the industry's revenues to national GDPs shows that it is equivalent to the third largest country in the world. The insurance sector perhaps is the world's largest industry.[6]

The mix of life-health versus property-casualty insurance vary widely among nations, with a 40/60 ratio on average, but the magnitude and growth rates of life insurance tend to be greater than those of property insurance. In response to the confluence of economic growth, population growth, and market liberalization, the insurance sector is growing particularly rapidly (significantly faster than GDP) in emerging markets (Figure 7).[7]

Figure 7. Insurance Demand is Growing Faster than GDP, Particularly in Emerging Markets



[4] Detailed country-by-country statistics (in U.S. dollars and local currencies) are published in Swiss Re's annual "World Insurance" reports (e.g., Swiss Re 2004).

[5] Data presented in this report represent western-style insurance and do not include the premium-equivalents that are collected from alternative systems, such as *Takaful* methods used in the Muslim world or so-called "self-insurance" which is often formalized and represents considerable capacity.

[6] The world oil market, for example, is $970 billion/year at current production levels of 76Mbod and $35/bbl price; world electricity market in 1996 was $1.3 trillion at 13 trillion kWh generation assuming $0.10/kWh unit price; tourism receipts were $445 billion in 1998; world military expenditures were $800 billion in 1995 (Source: 1999 Statistical Abstracts of the United States).

[7] For the period 1980 to 1998, South and East Asia was the fastest growing region with 15 percent per year growth for non-life insurance and 25 percent for life insurance. In Latin America, growth was 10 percent and 15 percent, and in Africa five percent and 15 percent, respectively. Trends in Eastern Europe were highly erratic for the post-1992 period for which data are available (Swiss Re 1999).

At current growth rates, emerging markets will represent half of world world insurance premiums by the middle of this century.

Historical data on the degree to which insurance is used to pay for extreme weather events show that approximately 30 percent of costs are insured in industrialized economies while only five percent are insured in emerging markets (Vellinga et al. 2001). In both developing and industrialized countries, the penetration of insurance by type of event varies, with most coverage for storms and least coverage for flood[8] and "other" events such as drought and wildfire. Approximately 45 percent of global storm-related losses were insured over the 1985-1999 period versus five percent of flood and 13 percent of "other." Some events go uninsured; e.g., global losses from drought and heat wave reached nearly $7 billion in 2002, and little or none of these losses was insured (Best's Review 2003).

The demand for weather-related insurance is growing. Expanding market segments include weather-derivatives applicable to utilities, crop production, and other weather sensitive businesses, insurance for the diverse impacts of power outages, and property insurance in areas with wildfire risk. Because of growing demand and affluence in developing countries and economies in transition, insurers from industrialized countries are rapidly moving into those markets. Insurance systems, however, are already challenged by natural disasters in wealthy countries where risk management and disaster preparedness are well developed. The outcome of this tug of war is key to determining the ultimate global role that insurers will seek to play in absorbing the costs of natural disasters.

The Consequences of Extreme Weather Events are Becoming Increasingly Globalized, in Part Because of the Structure of Insurance Markets.

Insurance is an integral part of the trend toward globalization, and U.S.-based insurers are leading the way, as measured by the magnitude of their participation in foreign markets. Current trends toward deregulation and liberalization in Asia (particularly China and India) and Eastern Europe as well as increasing wealth are fueling the growth of insurance.

Experience to date suggests that participation of foreign insurers will be important for the development of new insurance markets in developing countries and economies in transition. A statistical review by Swiss Re (2000b) found that growth of foreign insurers' premiums in emerging markets averaged more than 20 percent per year during the 1990s. During the late 1990s, the U.S. alone was collecting approximately $40 billion in premiums for policies placed overseas, with an average annual growth rate of 10 percent between 1990 and 1998 (III 2003).[9] Between 1990 and 2000, the market share of insurers that were either partly or fully foreign

[8] There is a common misconception that floods are entirely uninsured. Typically one-quarter of flood losses are paid by insurance, depending on the country in which they occur and the nature of the impacts. More than half of the economic losses from the massive Central European floods in 2002 were insured (Best's Review 2004). Definitional ambiguities often class flood-related losses as (insured) "storm" losses (Swiss Re 2003c).

[9] The leading insurers in this category include Aetna, AIG, CGU, Chubb, Cigna, Metropolitan Life, New York Life, and Prudential (Swiss Re 2000b).

owned tripled in Latin America and Central and Eastern Europe[10] to 47 percent and 41 percent, respectively, and to 12 percent in Asia.[11] Although they enjoy the considerable business potential of emerging markets, foreign insurers must also help pay the growing costs of extreme weather events, including the costs of flood, drought, wildfire, and the health impacts of these disasters.

Insurers domiciled in industrialized countries are also vulnerable to extreme weather events elsewhere through insurance of property or activities associated with international trade or commerce. Types of coverage affected range from political risk insurance to marine insurance and coverage for other weather-sensitive energy-sector activities such as those associated with the oil trade (SAI 2000). Natural disasters can also have ramifications for distant economies by disrupting supply chains and other increasingly interconnected market systems. In addition, insurance observers note that much-discussed government caps on emissions could result in liabilities for polluting companies, which could, in turn, manifest in on- or off-shore product liability, business interruption, or Directors and Officers insurance exposures (Aldred 2004a,b).

Reinsurance is another important element of global risk spreading. Reinsurance is the purchase of insurance *by* insurers, typically for losses in excess of a pre-agreed amount but also on a proportional basis, and is the means by which many insured risks (both life and non-life) are ultimately distributed (Reitz 2003). Because a given reinsurance company will assume risks from thousands of insurers around the globe, reinsurance is an inherently global segment of the industry. The world reinsurance market is projected to nearly double from $106 billion in premiums in1995 to $194 billion in 2010 (Duffy 2001).

Meanwhile, as noted earlier, international aid—a key pathway through which extreme-weather risks are becoming globalized—has not kept pace with the growth in demand for natural disaster relief. Importantly, international aid has been flat in the past two decades (at approximately $60 billion per year) and declining as a percentage of donors' GDP, while the inflation-corrected economic costs of natural disasters has increased eightfold. Moreover, most (if not all) aid goes toward recovery, and little is directed to proactive and preventive measures. In addition, foreign policy considerations mean that the majority of aid is designated for events other than natural disasters.

Insurance for Extreme Weather Events can be Coupled with Strategies that Contribute to Sustainable Development and Enhance Disaster Resilience.

Public-private partnerships can enhance the efficacy of both insurance and increase the pool of people who have access to it. In a relatively straight-forward example, commercial insurance companies in the U.S. are introducing flood insurance to complement that provided by

[10] Data for additional Central and Eastern European countries are provided in Munich Re (2000) and Swiss Re (2001b).

[11] Chile and Mexico have the highest penetrations. In Asia, the greatest shares are found in Malaysia, the Philippines, Indonesia, and Singapore (Swiss Re 2000b). In Central and Eastern Europe, Hungary and Poland have the highest penetration of foreign insurers.

government programs (McDonald 2003). More innovative examples include systems for delivering insurance to the poor (e.g., micro-insurance or small-denomination/low-cost weather hedges, e.g. for farmers in developing countries) combined with technologies and practices that simultaneously reduce vulnerability to disaster-related insurance losses and support sustainable development and reductions of greenhouse gas emissions. A strategy combining these elements was piloted in the Caribbean where USAID's Office of Foreign Disaster Insurance and NGOs provided trained homebuilders to construct hurricane-resistant housing, banks provided financing for construction, and insurers made coverage available where it had not previously been (Box 1). Other relevant products include insurance for predicted energy savings (Mills 2003b) and coverage for carbon-trading contracts, which is being developed by major insurers, including Aon (Aon n/d). Insurers have stated their receptivity to arrangements like these, noting the new imperatives presented by climate change (Munich Re 2004; UNEP and Innovest 2002).

Box 1. "Lessons Learned": The Caribbean Disaster Mitigation Project (CDMP)

Initiated in 1993, CDMP is a project of USAID/OFDA, implemented in several countries by the Organization of American States, to promote sustainable public/private disaster mitigation mechanisms that lessen loss of life, reduce potential damage, and shorten disaster-recovery periods. Project activities included support for national insurance associations in organizing technical conferences, disseminating hazard and risk information, and producing hazard and risk maps and information to promote safer location of development (USAID-OAS 1996). Beginning in 1998, Barbados-based United Insurance began a program in which homeowners and businesses can qualify for significant reductions in insurance premiums if they retrofit homes and buildings to better withstand hurricane wind forces. The project operated in Dominica, Saint Lucia, Saint Kitts/Nevis and Antigua, and Barbuda and trained 145 homebuilders (UNDP 2004). In the Antigua-Barbuda Pilot Project, 100 homeowners and three of the country's major insurers participated. In the Hurricane Resistant Home Improvement program, a U.S. non-governmental organization built capacity of local builders to offer disaster-resilient homes using home improvement loans from local banks. In St. Lucia, a group insurance policy was obtained for participants. Possibilities for leveraging efforts to date include incorporating village-scale measures with joint adaptation/mitigation qualities.

Strategies that contribute to public health and sustainable development by cost-effectively mitigating damage from (and thus costs of) natural disasters include curtailing deforestation, which reduces risks such as wildfire, malaria, mudslides, and flooding while also reducing emissions of greenhouse gases. Other strategies involve an intriguing combination of adaptation and mitigation; e.g., methods of reducing the vulnerability of buildings and their occupants to urban heat-island effects and acute heat catastrophes also tend to increase energy efficiency, thus curtailing greenhouse gas emissions. As an illustration of how these and others map to public-sector objectives, Table 2 relates the principles below to priorities stated by the U.S. Agency for International Development.

Table 2. Mapping Prospective Insurance Industry Activities on to USAID's Current Energy/Environment Objectives for Developing Alliances*

	Training & Capacity Building on Insurance & Risk Management	Innovative Insurance Products (e.g. Microinsurance, Energy Savings Insurance, Weather Derivatives)	Risk Mapping	Sustainable Forest Management	Sustainable Agriculture	Energy-Efficient, Disaster-Resilient Buildings & Farms	Energy-efficient Water Disinfection	Mitigating Urban Heat Islands	High-efficiency, Grid-Independent Lighting Systems
Improved Protection and Sustainable Use of Natural Resources									
Providing biodiversity conservation through on-the-ground conservation initiatives and dissemination of best management practices				●					
Improving the design and implementation of policies that affect biodiversity use and conservation				●					
Providing technical assistance to field missions in strategic planning, program design, and monitoring of biodiversity programs	●								
Reducing damage to forests by inappropriate wood harvesting techniques				●					
Promoting rehabilitation of degraded land					●				
Increasing local participation in forest and tree system management				●					
Establishing integrated monitoring and assessment of forest resources to conserve biodiversity and improve forest health.			●						
Strengthening the individual and institutional capacity of non-governmental organizations (NGOs), community-based organizations, and government institutions involved in freshwater and coastal resources management		●							
Promoting new initiatives that help communities identify, value, and better manage freshwater and coastal resources under their control		●	●				●		
Increasing public awareness of and participation in freshwater and coastal resources management	●								
Improving the design and implementation of policies that affect water use	●				●				
Create low-cost/low-maintenance water treatment and disinfection systems							●		
Improved Management of Urbanization in Target Areas									
Improving living conditions and minimizing disaster risks, especially for urban slum settlements						●		●	●
Increasing equitable delivery of water, electricity, and waste disposal services							●		
Expanding the private sector's role in partnering with cities to provide services and shelter for the poor		●						●	
Incorporating people and community needs into urban management			●			●		●	
Increased Environmentally Sustainable Energy Production and Use									
Promoting energy efficiency and environmental management systems in cities, transport and industry						●		●	●
Expanding electrification activities to rural and economically disadvantaged urban areas							●		●
Fostering implementation of policy and regulatory changes that clarify or establish rights and incentives for the cost-effective utilization of renewable energy resources and technologies		●				●	●		●
Developing productive use of energy in applications such as irrigation pumping, drip irrigation and processing agricultural commodities, communications, and information technologies						●			
Improving public and private sector institutional ability to administer the energy sector, allow for more effective delivery of energy services to rural and urban populations, and expand improved urban environmental management systems		●				●	●	●	●
Reduced Threat to Sustainable Development from Global Climate Change									
Advancing approaches that promote climate-friendly technologies and carbon sequestration through innovative energy, forestry, and agricultural practices				●	●	●	●	●	●
Developing projects that reduce greenhouse gas emissions through cost-effective interventions				●	●	●	●	●	●
Mitigating impacts on food production, human health, the natural resource base and coastal areas caused by climate change, land use change, and long-term changes in precipitation patterns	●	●	●	●	●	●	●	●	●

Humanitarian Assistance, Economic Growth and Trade Capacity Building, Education, Environment/Energy, Health, Information Technology." Annual Program Statement, APS

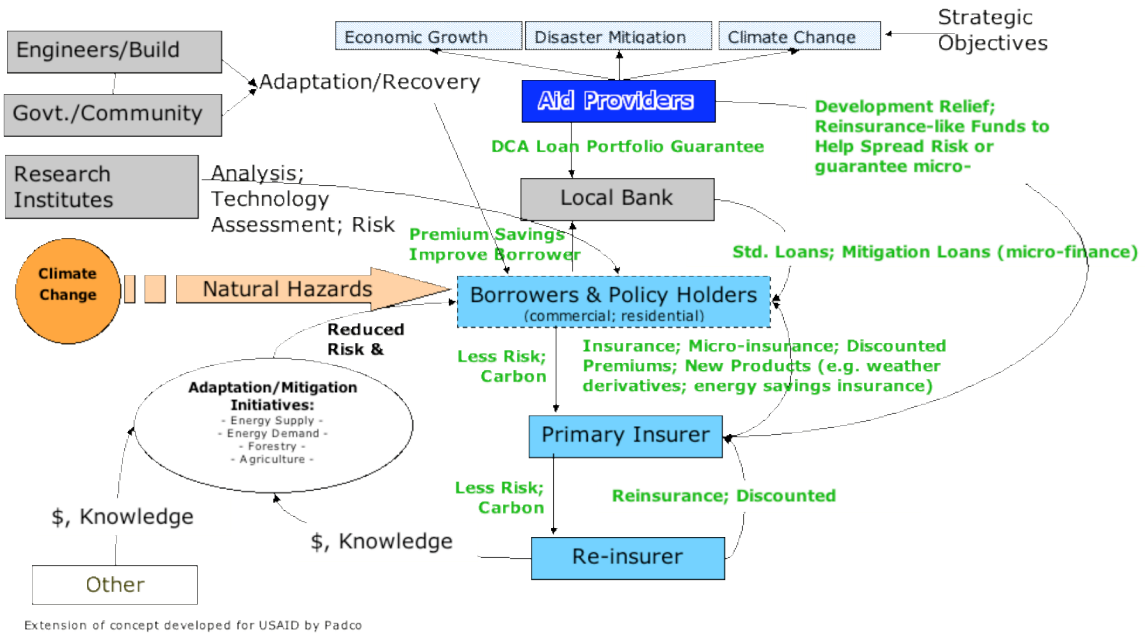
Strategies that Combine Climate-Change Adaptation and Mitigation

Considerable thought has been given to identifying disaster-management strategies that also support sustainable development. Examples include protection of mangroves, reefs, and beaches that buffer storm surge and wave risks; and forestry and agricultural practices on mountain slopes that reduce flood and landslide risk (Aalst and Burton 2002). Less effort has been devoted to identifying strategies that also reduce greenhouse-gas emissions (Mills 1996; Mills 2003a).

Some have argued that insurance will drive many of the adaptations to climate change (Milne 2004) and that it could become a major force in climate change mitigation strategies as well (Mills 1996). In fact, insurers can promote joint mitigation/adaptation technologies and practices in a variety of ways. The most direct way is through rewarding those who adopt these technologies and practices, using financial incentives in the form of lower premiums, higher deductibles, etc. There are other methods as well, such as channeling information to insurance customers and promoting improved building codes and land-use planning (both of which have a long history of insurer involvement). There is considerable precedent for such activities among North American and European insurers (Mills 2003a).

An overarching theme is to help condition markets to manage risk so that insurance or insurance-like risk-spreading systems can be introduced successfully and in a sustainable fashion. The activities listed below are suggestive rather than comprehensive, and the categories and initiatives are not ranked. Cross linkages or combinations of the activities described can be readily imagined. Figure 8 is one conceptualization of the flow of knowledge and financial resources among the actors that could to foster attainment of these goals.

Figure 8. New Public-Private Systems Could be Created to Couple Climate Change Adaptation-Mitigation, Economic Development, and Risk Management



Following are examples of synergisms between adaptation and mitigation for which there is a natural involvement by the insurance industry. Items are grouped into two overarching categories: The Energy Sector and Agriculture, Forestry, and Land Use. A summary is given in Table 3.

Table 3. Characterization of Adaptation-Mitigation Co-benefits, and Insurance Lines of Business Effected.

SECTOR > Strategy	MITIGATION BENEFIT	ADAPTATION BENEFIT	TYPES OF INSURANCE BENEFITS
Energy Sector -- Demand Side			
Energy efficiency generally	reduced energy use	Grid reliability	Business interruption, contingent business interruption, service interruption, boiler and machinery, perisha
Natural ventilation; daylighting	reduced energy use	Allows continued facility occupancy during power outage	Business interruption
Insulated ceilings in cold climates	reduced heating energy	Structural integrity and extended habitability of structures during natural disaster	Property, business interruption
Heat island mitigation, e.g. via reduced roof albedo and urban forestry	reduced air-conditioning energy	Extended habitability of structures during heat waves; moderation of precipitation (urban trees) and reduced flash flooding, reduced smog formation due to lower temperatures	Health, Life, Relocation expenses; business interruption
Efficient grid-independent lighting	reduced electricity use	disaster recovery	Business interruption
Efficient windows	reduced space-cooling energy	Improved fire-resistance and reduced vulnerability to wind-blown debris	Property
Energy Sector -- Supply Side			
Renewable energy systems	reduced energy use	Grid reliability	Business interruption, service interruption, cyber-risk insurance (data loss), worker's compensation, property loss, liability, perishable goods interruption.
Distributed energy systems	reduced electricity transmission losses (and thus energy use)	Grid reliability	Business interruption
Hydroelectric systems	reduced ghg emissions	Flood control	Property, life/health
Biomass energy plantations	carbon sinks		
Agriculture, Forestry, and Land Use			
Agricultural soil management	soil carbon content	Enhanced drought-resistence	crop
Land restoration and afforestation	carbon sinks	Reduced flood/mudslide risk	property, crop
Mangrove protection/restoration	carbon sinks	Enhanced flood and tidal-surge resistence	property, life/health
Health (Human and Other Systems)			
Improved forest management	reduced wildfires (carbon emissions)	Reduced habitat for malaria vectors; flood control; reduced vulnerability to forest pests; retention of disease vectors (e.g. bats--Nipah virus) otherwise hazardous to humans	Health, life, property
Ultraviolet water disinfection	reduced commercial energy use; reduced deforestation	Ability to respond to water quality crises following extreme weather events	Health, life

The Energy Sector

Energy infrastructure—particularly electric power systems—is distinctly vulnerable to natural disasters, as well as to gradual climate changes. This is particularly so for traditional, centralized systems that are vulnerable both because, for example, a single disruption to a power plant or refinery affects a very large population of end users and because damage to the transmission or distribution side can isolate an otherwise functioning central facility from end-users. Fossil-fuel production facilities (particularly off-shore units) and energy transportation systems (shipping, pipelines, etc.) are also vulnerable. Subsidence caused by the melting of permafrost is a risk to

oil pipelines and electricity transmission towers. Ice Storms can cause electrical system disruption, as was witnessed in the storm in the Northeast US in 1998, an El Nino year (Lecomte et al. 1998). During the catastrophic European heat waves of 2003, electric power plant activity had to be curtailed because of elevated cooling-water temperatures (Munich Re 2004). End-use loads "downstream" from energy production and distribution, particularly space-cooling, are also vulnerable.

Power outages are one of the more important emerging insurance risks, witnessed by the 2003 outage in North America which left 50 million people without power, resulting in $180 million in insured losses and up to $10 billion in total losses (Fletcher 2004). A recent survey found that power outages cost half of the companies $50,000 per hour of downtime, and over $250,000 for the top quartile (Risk Management 2003). Italy experienced an even larger outage later the same year, with other major outages in London and parts of Scandinavia (Wade 2004). Losses can range from various forms of business interruptions; to property losses from consequent fires (61 more fires than normal during the 2003 US blackout), data loss, equipment damage from power surges, and loss of perishable refrigerated products; to injury from evacuations; to liability for power suppliers deemed to have been able to avert the loss. Business interruptions are particularly significant, e.g. Ford Motor Company stated that more than half of its 44 plants in North America were shut down by the outages of 2003, and others (out of the area of the outage) were adversely impacted by disruptions to supply lines. All other major car manufacturers in the Detroit area were also shut down (Bradford 2003).

While arguably not as "brittle" as centralized energy systems, renewable systems can have their own vulnerabilities, e.g. wind-power systems may are intentionally placed in the path of the greatest wind corridors and are thus vulnerable to increased intensity of storms (UKCIP2003). Biomass-based systems are vulnerable to interruptions of fuel supply due to drought, flooding, or other hazards impacting fuel distribution or growing areas. Hydroelectric power systems are clearly dependent on the precipitation, runoff conditions, and siltation rates for which they are designed, and may thus be impacted by changing climatic conditions, while flooding can cause damage to hydroelectric infrastructure.

With the preceding caveats, adaptive capacity may be enhanced by strategically developed distributed power generation and renewable energy systems. Similarly, increases in energy efficiency at the point of end-use decrease average and peak demands on electricity grids. Goldman et al. (2002) found that Californians reduced electricity usage by 6% and monthly peak demand by 8% in response to the impending power outages of summer 2000, and even more the following summer. This demand response—which translated into 50 to 155 hours of avoided rolling blackouts—contributed to avoiding an estimated economic loss as high as $20 billion.

The synergisms between energy-efficient strategies and climate change adaptation have been treated in some depth elsewhere (Mills 2003c). These include concepts such as reducing rooftop ice damming with better insulation or the fire-resistance of energy-efficient window systems. Following are illustrative examples of how this thinking can be extended to insurance-relevant applications in emerging and industrialized markets.

Following are illustrative examples:

Figure 9. USAID "Warm-Dry Rooms" Project

Warm-dry rooms in Kosovo helped residents remain in their homes throughout the winter (photo by Charles Setchell. USAID/OFTA).

- *Embed sustainable technologies in disaster recovery activities.* USAID/OFDA's shelter specialist devised "Warm-Dry Rooms" for 22,000 families during the crisis in Kosovo between 1998 and 2000 (Figure 9) (OFDA 2002). Warm, dry rooms were created in existing structures as an alternative to creating displaced-persons camps, thereby maintaining the cohesion of communities while providing employment to those constructing the rooms. Augmenting such strategies with high-efficiency space-heating strategies would increase the number of families that could be served with finite heating-fuel supplies.

- *Promote energy-efficient water disinfection for disaster recovery.* Approximately a decade ago, USAID provided seed funding to develop a new disinfection technology that would remove waterborne diseases using significantly less energy than traditional methods. The result was "Ultraviolet (UV) Waterworks." a small-scale system that can operate on or off of the electricity grid (Figure 10). UV disinfection reduces pressure on fuel-wood resources, and thus is important to efforts to curb deforestation, which reduces carbon sinks and increases net emissions.[12] Applications have also been seen in industrialized countries, where water supplies are also compromised during disasters where flooding mobilizes pollutants or power losses disrupt water delivery and waste-management infrastructure.

Figure 10. Energy-Efficient UV Water Disinfection System

Source: http://www.waterhealth.com/emergency_relief.htm

- *Incorporate one-watt lighting systems in disaster relief, promoting independence from kerosene and batteries.* Nearly two billion people are dependent on liquid fossil fuels for lighting, a source of approximately 250 million tones of CO2 emissions annually (Mills and Johnson 2002; Cool 2003). Supplies of these fuels can be easily disrupted during natural disasters, impeding the disaster-recovery process. New light-emitting diode (LED) technologies make it possible to provide high-quality battery-driven (or even battery-independent) light supplies that are far more efficient and cost effective than

Figure 11. White LED Lighting System in Nepal (left) and Prototype Solar-PV Units (right)

Photos courtesy: Stewart Craine (left) and Stanford Alumnis Magazine (Right)

[12] See http://eande.lbl.gov/IEP/archive/uv/index.html

versions currently in use (Figure 11). In extreme weather events, these systems would be valuable in disaster-recovery situations (both for aid workers and for impacted citizens, in homes or in camps for dislocated people). Typical solar/fluorescent lighting systems are deemed too expensive and have questionable durability in these contexts. Emergency lighting applications in industrialized countries would help reduce business interruptions and injuries during evacuations.

- *Mitigate urban heat islands.* Lightening the coloration of roads and rooftops reduces ambient urban air temperatures, which reduces smog formation and lowers the risk of mortality during heat catastrophes. The need for mechanical air conditioning is reduced, to some degree. Moreover, urban trees reduce runoff and hence the risk of flash flooding.

- *Support afforestation using biomass energy plantations*. This would support renewable energy production, flood/landslide management, soil/water conservation goals, and carbon sinking objectives.

- *Deploy distributed renewable energy systems to enhance electricity-system reliability.* Distributed renewable energy generation systems (e.g., micro-hydro, wind, solar thermal, and solar electric power) are largely invulnerable to grid and fuel-supply disruptions. In the wake of the massive U.S. blackouts of summer 2003, insurers acknowledged the potential benefits of renewable energy (Sullivan 2003). This is particularly important in light of an increased awareness of the risks of wide-area power outages (Aldridge 2004) and a trend towards reductions in business interruption insurance availability (Lenckus 2004).

Agriculture, Forestry, and Land Use

• Sustainable Forestry Practices: Wildfire Management, Flood Risk Reduction and Enhanced Hydroelectric Power Production. Many studies have linked environmental degradation (including deforestation) with increased vulnerability to natural disasters (e.g., hurricanes and mudslides). For example, wildfires caused by slash-and-burn deforestation are both a source of net carbon emissions and a natural hazard for property and health. (See Portela and Aguirre 2000 for several examples specifically related to Cuba.) Indonesian wildfires were associated with the spread of Nipah virus (via dislocated fruit bats moving into human settlements and agricultural areas).

In many parts of Asia, Africa, and Latin America, deforestation has released silt into rivers that seriously impacts hydroelectric turbines and reduces reservoir capacity, among other problems. If effectively managed, future increases in runoff could mean more power generation. However, if runoff is a result of increased variability in climate (as expected under climate change), rather than increased average flows, more uncontrolled spills (floods) are expected. Effective forest management in certain watersheds would decrease the likelihood of flooding.

A watershed with diverse vegetation will more effectively buffer a reservoir from rapid influxes of runoff than will a deforested watershed. If rapid influxes are prevented, the reservoir may be able to produce more power on an annual basis because operators can run

more water through the turbines instead of spilling it during heavy flooding episodes. An important collateral benefit is that reduced silting means overall storage capacity of the reservoir is maintained, preventing overflow flooding and extending the life of the facility.

There exists some precedent within the insurance sector for the aforementioned types of projects. Storebrand—Norway's largest insurer—has invested in sustainable forestry projects (Storebrand n/d). Similarly, in partnership with the Swiss Association for International Cooperation, Swiss Re contributed to the planting of 650,000 trees in Haiti,[13] to help counteract the detrimental effects of deforestation and erosion on drinking water.

- Dry-land Farming Adaptation in Drought-prone Regions to Enhance Food Security, Preserve Water Quality, and Conserve Carbon in Soils. Agricultural soil conservation measures reduce runoff, erosion, and vulnerability to drought. Insurers could support these efforts by providing crop insurance if there is none or reducing premiums if crop insurance is already available. A similar approach could be explored for weather derivatives. USAID's Natural Resource Investment Fund Project (FIRENA) is reported to be conducting a successful pilot project in the Dominican Republic (Aalst and Burton 2002).

Innovative Insurance Products & Financing

Insurers are, by definition, interested in preventing losses rather than paying to repair post-event damages. The availability, terms, and pricing of insurance can send signals that encourage practices that enhance disaster resilience; this is often the case in advanced insurance markets (e.g. good-driver discounts). Practices that can be encouraged include the use of early-warning systems, building codes (and their enforcement), land-use planning, sustainable forestry approaches, and the types energy-related measures described in the preceding section that inherently improve disaster resilience, e.g., by reducing reliance on grid-based power. In addition, for the billions of people who have no insurance, new types of insurance products—e.g. micro-insurance—should be developed (World Bank 2000).

There are specific ways in which new or existing insurance products can be used to promote increased use of sustainable practices, as follows:

- Crop Insurance, Sustainable Agriculture, Enhanced Food Security and Carbon Sequestration. According to a UN presentation at the World Summit on Sustainable Development (UN2002) "in rural programmes and drought-prone areas, specific attention should be paid to food security and the promotion of agriculture techniques and inter-cropping that reduce hazard-related agriculture losses." Sustainable agriculture activities tend to increase carbon storage in soils, thus providing dual adaptation/mitigation benefits. New initiatives could foster such practices through linkages with either public- or private-sector-provided crop insurance.

- Weather Derivatives and Other Hedging Tools. A panel of insurers convened by the UN noted that climate change could offer opportunities for the weather-derivatives market (Zolkos 2002).

[13] http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=./alldocbyidkeylu/SBAR-59FLV7

Other observers have stated that weather derivatives may be preferable to traditional insurance in some cases, given the linkage to a predetermined trigger regardless of the scale or nature of damage, rapidity of payouts, etc. (Benson and Clay 2002). Investors in renewable energy technologies will be particularly interested in these products, as weather is a key determinant of performance and profitability (Aldred 2004a,b). However, serious concerns have been raised about the viability and credibility of the weather-derivative business model (Swiss Re 2002a), and a major case of fraud was recently uncovered spanning several countries (McLeod 2003). Care should be taken in evaluating potential applications.

- Insurance for Renewable Energy Systems. Capital projects, including those involving renewable energy are vulnerable to natural disasters and other types of risks. Major insurers and brokers such as Aon (Aldred 2000a), are becoming involved in providing coverage and perhaps other forms of risk management to projects established to achieve greenhouse-gas emissions reductions. Swiss Re has investigated providing professional liability insurance to firms that provide verification and measurement services for carbon-trading arrangements (Sclafane 2001).

- Development of Markets for Energy-Savings Insurance (ESI). Insurers in North America have begun to provide what is known as "Energy-Savings Insurance." which addresses performance risks in traditional energy-savings investments by warranting performance in exchange for a premium (Mills 2003b). There is a potentially large market for ESI in emerging markets (and analogous renewable energy and cogeneration performance insurance products), especially because performance risks could be particularly high there. One benefit of ESI is that it can operate essentially as a loan guaranty in cases where debt service is indexed to the anticipated energy savings. This can translate into favorable borrowing terms. By analogy, AID's Development Credit Authority has guaranteed loans for energy efficiency, which has been seen as beneficial by local banks.

The Potential for New Patterns of Extreme Events Resulting from Climate Change will likely Increase Demand for Insurance while Challenging the Industry's Ability to Assume New Risks.

Insurers have expressed concern about climate change since as early as 1973 (Munich Re 1973). Since that time, insurers have seen property-casualty claims from natural disasters (corrected for inflation) rise considerably compared to other losses. (Corresponding life-health insurance loss trend data are generally not available, owing largely to their diffuse, non-catastrophic nature.) Coupled with the growing rate of losses, insurers expanding into emerging markets also encounter actuarial uncertainties posed by the increasing volatility of weather events (see Figure 12**)** associated with global climate changes as well as the greater exposures and vulnerabilities of emerging markets to these disasters.

Regardless of whether climate change is a result of human activities or natural variation in weather patterns, the observed increase in uncertainty regarding the intensity, frequency, and location of extreme weather events confounds the fundamental actuarial processes that underlie well-functioning insurance markets. Increased uncertainty can thus call into question the fundamental insurability of certain risks, which may have the result of limiting the availability of

insurance. Climate change is a significant concern for both the property-casualty and life-health segments of the industry, perhaps more so for the latter segment because of its relatively larger size and growth rate, and the implications of climate change for morbidity and mortality.

Figure 12. Insured Losses from Natural Hazards Are Less Predictable Than Conventional Losses (Central Europe: 1983-2002)

Source: Swiss Re 2002g

Limitations to insurance's effectiveness in addressing these issues also include the short timeframe of insurance contracts and the ease with which insurers can withdraw from or increase prices in markets perceived as overly risky. Moreover, the insurance industry itself is vulnerable to extreme weather events and climate change, and its capacity to absorb risk varies depending on recent losses and other market factors. Nonetheless, insurers have historically used risk management and loss-prevention techniques to reduce business risks in particular market segments, while growing their business even in the face of increasing risks.

Conclusions

The view that climate change is a strategic business risk is more prevalent in the insurance industry than any other component of the financial services sector (UNEP and Innovest 2002). However, according to a group of 90 concerned insurance companies working under the auspices of the United Nations Environment Programme (UNEP), insurers and reinsurers have not yet broadly responded to calls to help emerging markets prepare for and respond to climate change. The UNEP insurers' group argues that proactive steps would be in the industry's financial interest and consistent with the industry's underlying principles of risk management.

It is widely recognized that lack of information is one of the central barriers to improved adaptive capacity to natural disasters (Smit et al. 2001). Beyond the growing number of exemplary industry leaders, many members of the insurance industry have thought little, if at all, about the nexus between extreme weather events, and climate change; these participant in the industry could benefit from focused communications efforts (UNEP and Innovest 2002).

Increased collaboration between the insurance and climate-modeling communities could significantly improve the quality of data and risk analysis, facilitating increased availability of insurance in regions where a current lack of information is an obstacle to market development. With such information in hand, the insurance industry could increase its efficacy as a channel of information on disaster preparedness and recovery for their customers. The importance of improved data and modeling is central, as evidenced by a shift in the industry (thanks in part to better models) towards accepting flood risks where they previously had been viewed as uninsurable (Swiss Re 2003e).

Involving the insurers of extreme weather events in the development and execution of strategies that contribute to public health and sustainable development would enhance disaster resilience, reduce the magnitude of losses, and thus help increase insurers' willingness to establish, maintain, and expand a constructive presence in emerging markets. We offer the following principles for establishing priorities and creating effective projects in insurance and sustainable development:

- Focus on efforts that enhance the fundamental insurability of weather-related risks.
- Couple insurance efforts with core development activities.
- Foster efficient domestic government and private insurance risk sharing.
- Utilize public-private partnerships.
- Build domestic/local insurance and risk-management capacity.
- Discourage complacency in response to insurance availability or government aid
- Respond to insurers' regional priorities.
- Address life and health insurance issues along with those related to property damage.
- Raise awareness within the insurance sector.
- Harness market-pull forces (e.g., foster aggregated demand for insurance products)
- Understand insurers' relationship to the security implications of climate change.

A constructive starting point for enhancing market opportunities for insurance of natural disasters is to address ways in which current or anticipated risks are perceived as uninsurable. Table 4 scopes the issue of insurability and illustrates specific strategies to address such concerns, including activities such as improving the modeling and data on disaster exposures and potential costs, establishing and enforcing improved building codes, establishing solvency regulation for insurers to obtain an appropriate balance between operating profitability and reserving for major losses, and providing for early warning systems and disaster-recovery assistance. An example of a government initiative to enhance insurability is Puerto Rico's Reserve for Catastrophe Losses, under which a portion of which property insurance premiums is passed to a trust. According to Auffret (2003), "it is anticipated that this mechanism will improve the availability and affordability of catastrophe reinsurance and reduce the dependency of Puerto Rican insurers on foreign reinsurance."

The success or failure of insurance also depends on the political, fiscal, and regulatory environment (Mills et al 2002).[14] Examples of regulatory interventions include restrictions on pricing, the types of investments insurers can make, limitations placed by host countries on access to international markets, and allowable reserve accumulations (Auffret 2003). Effective insurance regulation must strike a balance between allowing insurers an attractive return on their business activities and ensuring their solvency (and ability to pay claims) in the event of major losses. Other needs include regulatory policies that support fiscal transparency and responsibility, and measures that can garner the trust of the insurance-buying public.

As insurers have many "fires to fight," and environmental issues such as natural or human-induced climate change must compete for attention with other critical issues, key target markets (economic, demographic, and geographic) should be identified, and proposed initiatives should clearly define their relevance to the insurers. Collaborations should include insurance brokers and other important trade allies. It is incumbent on public entities seeking partnerships with insurers to establish and demonstrate the value of these partnerships.

[14] For example, the introduction of tax-deductible life insurance premiums boosted the premium growth rate in Mexico and in Brazil (Swiss Re 2003a). In contrast, financial crises can dampen insurance markets in various ways.

Table 4. "Insurability" as it Pertains to Climate Change.

Conditions Contributing to Insurability	**Means of Achieving Insurability**
Assessable Risk: Insurers must understand the likelihood and estimated magnitude of future claims and be able to unambiguously measure the loss. This is essential for pricing, especially where regulators require that premiums be based strictly on historic experience (rather than projections). For example, some insurers and reinsurers currently avoid Asia and South America but have expressed interest in expanding into these regions if loss and exposure information become more available (Bradford 2002)	• Improved data (e.g., flood zone mapping) and climate/impact modeling for developing countries and economies in transition.
Randomness: If the timing, magnitude, or location of natural disasters were known precisely, the need for insurance would be reduced and the willingness of insurers to assume the risk would vanish. Intentional losses are not insurable. If losses can be predicted, only those who were going to make claims would purchase insurance, and insurance systems would not function.	• Statistical and monitoring systems. • Accountability and legal remedies for insurance fraud.
Mutuality: The insured community must sufficiently share and diversify the risk. The degree of diversification for one insurer is reflected in the number of insurance contracts (or the "book of business" in insurance parlance), geographical spread, etc. The larger the pool, the greater the reduction of loss volatility. Such risks must also be uncorrelated so that large numbers of pool members do not face simultaneous losses.	• Create sufficiently large and diversified pools of insureds.
Adverse Selection: Insurers need to understand the risk profile of the individuals in their market and be able to differentiate the exposures and vulnerabilities of the various customer subgroups. This can form the basis for differentiating premiums or coverage offered. Lack of this information or use of insurance only by the highest-risk constituencies creates elevated risk for insurers, thereby putting upward pressure on pricing and affordability/availability. A key example is the lack of attention to the geographical concentration of risks preceding the 9/11 disaster (Prince 2002) and the ensuing public debate on the insurability of terrorism risks.	• Gather market data on vulnerabilities and associated demographic and geographic distribution of risks. • Differentiate premiums among different (risk) classes of insureds. • Rely on government insurance or co-insurance (e.g., U.S. flood insurance program)
Controllable Moral Hazard: The very presence of insurance can foster increased risk taking, which can be thought of as "mal-adaptation" to potential changes in weather-related events, which will, in turn, increase losses. This is an issue whether the insurance is provided by a public or private entity. The use of deductibles is the standard method of ensuring that the insured "retains" a portion of the risk. Moreover, the insured must not intentionally cause losses.	• Use of fixed deductibles (insured pays a fixed amount of any loss) • Use of proportional deductibles (insured pays a percentage of all losses) • Use of caps on claims paid • Education and required risk reduction
Managable Risks: The pool of potentially insurable properties, localities, etc. can be expanded if there are technical or procedural ways to physically manage risk.	• Building codes and enforcement • Early warning systems • Disaster preparedness/recovery systems
Affordability: "Affordability" implies that a market will be made, i.e., that the premiums required will attract buyers. If natural disaster losses or other weather-related losses are too great and/or too uncertain, an upward pressure is placed on prices. The greatest challenge is insuring poor households and rural businesses. This is evidenced by the ~50 percent increase in life insurance premiums in Africa in response to the AIDs epidemic (Chordas 2004).	• Micro-insurance or other schemes to facilitate small insurance for small coverages. Systems must maintain solvency following catastrophic events. • Government subsidy of insurance costs; provision of backstop reinsurance
Solvency: For an insurance market to be sustainable (and credible), insurance providers must remain solvent following severe loss events. Natural disasters have caused insolvencies (bankruptcies) among insurers in industrialized countries (Mills et al. 2001), and insurers in emerging markets are even more vulnerable. Solvency has been eroding for other reasons, particularly in the U.S. (Swiss Re 2002a)	• Solvency regulation (e.g., to ensure sufficient capital reserves and conservatism in how they are invested) (Swiss Re 2001b) • Risk pooling; Government insurance • Insurer rating systems
Enforceability: Trust and contractual commitments underpin the successful functioning of insurance markets. Insureds must be confident that claims will be paid, and insurers must receive premium payments. Recent large-scale fraud in the weather derivatives market underscores this issue (McLeod 2003). Many transitional economies, e.g., China, still have sufficiently unformed legal systems (Atkinson 2004).	• Contract law • Customer advocates • Regulatory oversight of insurance operations, pricing, claims processing

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